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OBSERVATIONS ON THE TRICHINA SPIRALIS.

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[REPRINTED FROM THE EDINBURGH MEDICAL JOURNAL, SEPTEMBER 1860.]

SINCE the year 1835, when Professor Owen first described the occasional existence of that remarkable entozoon, the trichina spiralis, in the muscles of man, the attention of many anatomists and pathologists has been directed to the subject. By the inquiries, more particularly of Owen,¹ Farre,² and Rainey and Bristowe³ in this country, and of Luschka⁴ and Virchow⁵ in Germany, the structure of the worm, its characteristic cyst-like envelope, the peculiarities of its habitat, and its mode of degeneration, have been carefully described, so that our information on these points may be regarded as almost complete. Moreover, the researches of other observers have shown that the trichina is not limited in its distribution to the muscles of man, but that it affects those of the other vertebrata. Thus Bowman⁶ has seen it in the muscles of an eel, situated within the sarcolemma; J. B. Chaussat⁷ has found it in the muscular coat of the stomach of the common frog; Herbst⁸ has detected it in the voluntary muscles of the cat, dog, and badger; and I am indebted to Professor Rolleston of Oxford, for a preparation of a portion of a muscle of the hedgehog, in which trichina cysts were imbedded. A great mystery has, however, always attached itself to the manner of development of the worm, and many ingenious hypotheses have been framed to account for its presence in the muscles.

Attempts have occasionally been made to solve this question by

¹ *Transactions of Zoological Society*, vol. i. Article, "Entozoon," in *Todd's Cyclopædia*.

² *London Medical Gazette*, Dec. 1835.

³ *Transactions of Pathological Society*, vol. v., 1854.

⁴ *Siebold and Kölliker's Zeitschrift*, vol. iii., 1851.

⁵ *Archiv*, vol. xviii., 1860.

⁶ *Philosophical Transactions*, 1840, and article, "Muscle," in *Todd's Cyclopædia*.

⁷ *C. R. de la Soc. de Biologie*, vol. i.

⁸ *Annales des Sciences Naturelles*, 1852.

experiment. Thus, in 1852, Herbst gave to three young dogs portions of the muscle of a badger in which trichinæ were imbedded. After the lapse of several months the dogs were killed, and their flesh was found to contain numerous trichinæ. From the uniformity of distribution of the worms in the muscles, Herbst supposes that the germs must have been carried to the muscular system through the agency of the blood, although he acknowledges the difficulty of explaining how the comparatively large ova of these worms were absorbed from the intestinal canal into the vascular system, and then extruded into the muscular apparatus.

During the last few months several experiments have been performed in Germany by Virchow,¹ Leuckart,² and Zenker,³ which have apparently cleared up many of the difficulties which previously surrounded the question. These experimenters have administered to various animals, such as pigs, rabbits, and dogs, flesh containing trichinæ. Some of the animals were killed within the first week after the feeding, and in the intestinal mucus, especially of the duodenum and jejunum, numerous minute and delicate thread-like worms were found, which they regard as free trichinæ. Many of these worms possessed complete sexual development. In some of the specimens examined by Virchow ova were found, in others semen cells. In Leuckart's and Zenker's experiments the worms were still further developed, so that some of the ova within the females contained embryos rolled up spirally, hence the conclusion was drawn that the trichina is a viviparous worm.

The muscles of several of the animals, which were allowed to live about a month after the feeding, were observed, on examination, to contain numerous trichinæ; and, in the case of a pig fed by Leuckart, shortly after the flesh had been administered to it, symptoms of an affection of the intestinal canal manifested themselves. On making the section of this animal, four weeks after the feeding, indications of a spent attack of peritonitis were seen.

Zenker also relates a very remarkable case of a young woman, admitted under his charge into the Dresden Hospital, suffering from febrile symptoms, with abdominal pain and tympanitis. These were rapidly followed by great muscular pains and œdematous swellings, especially of the extremities. The patient died about a month after the commencement of the illness; and, on making a *post-mortem* examination, the muscles were found to contain large numbers of non-capsulated trichinæ. The intestinal mucus from the jejunum of this patient also presented, when examined microscopically, numbers of small worms, which closely corresponded to the trichinæ of the muscles. They proved to be viviparous, for in the middle part of the bodies of the females completely developed embryos were found.

¹ *Archives*, vol. xviii., pp. 330 and 535. 1860.

² *Transl. in Quarterly Microscopical Journal*, July 1860.

³ *Virchow's Archives*, vol. xviii., p. 561. 1860.

On inquiring into the history of this woman, it was discovered that, four days before the commencement of her illness, she had partaken of sausages prepared from the flesh of a recently killed pig. Portions of sausage from the same animal were obtained and examined by Zenker, when they were seen to contain numerous capsulated trichinæ.

The following conclusions have been drawn from the above observations and experiments:—That the trichina, as met with in the muscular tissue, represents the immature condition of a nematoid worm; that, shortly after it is taken into the intestine, it becomes fully developed, and produces numerous thread-like worms, which, after a few days, bore their way through the intestinal walls, and finally reach the voluntary muscular fibres, where they become capsulated.

A subject, the muscles of which contained numerous specimens of the trichina spiralis, having been received into the dissecting rooms of the University during the present summer, I took the opportunity of verifying the experiments already detailed. The worms were observed to move, though somewhat languidly, on rupturing the cysts.

Experiment 1.—Gave to a kitten, on July 7th, portions of trichina flesh. The animal died about thirty-six hours after. On examining the intestinal canal, several specimens of *ascaris mystax* were found at its upper end, but no visible remains of the trichinæ. On placing a drop of the mucus under the microscope, several ova were seen lying free in it; this observation was repeated in the mucus taken from different parts both of the large and small intestine, and, in almost every instance, one or more ova were found in the specimen examined.



Fig. 1. Free ova from the intestinal mucus of a kitten, $\times 195$ diam.

Fig. 2. Ovary from the generative tube of an *ascaris*, $\times 195$ diam.

Fig. 3. Worm from the intestinal mucus of a cat, $\times 195$ diam.

Fig. 4. Cyst containing worm from muscle of a cat, $\times 80$ diam.

Fig. 5. Nuclei and granular matter from interior of trichina cyst of cat, $\times 195$ diam.

In each ovum (Fig. 1) a distinct nucleus was visible, surrounded by more or less granular matter, between which and the external investing membrane there was generally a clear space, varying somewhat in its extent. It is difficult to account for the origin of these ova. At first it was supposed that they might be derived from the ascarides present in the gut; but a comparison of their size and appearance with the ova within the generative tube of the ascaris, at once showed that this was not the case, as the latter, in addition to having the granules diffused much more uniformly through them, were also very much larger (Fig. 2).

Although no remains of trichinæ or their cysts were discovered in the intestine, yet it could not be doubted that the animal had swallowed many of them, for it was seen to eat the flesh freely; a sufficient length of time had elapsed between the feeding and death of the kitten to allow of their excretion. Are these free ova, then, to be regarded as derived from the trichinæ? To this question it is difficult to give an exact reply; for it may be objected, that the observations already related in a former part of this paper show that the trichina is a viviparous worm, the ova developing within the body of the worm, and not in the surrounding medium in which it lives. Although I am unable to offer any satisfactory explanation of the origin of these ova, I think it right to record the fact of their existence.

Experiment 2.—Administered to a cat on July 7th, 13th, and 16th, portions of trichina flesh, in the intervals feeding it on bread, milk, and fish. It is doubtful whether on the two last occasions the trichinæ were alive. Killed the cat July 24th. In the jejunum several specimens of ascaris mystax were found, and in the ileum a small tænia, but no remains of trichinæ cysts. The intestinal mucus presented to the naked eye nothing remarkable; but on placing a drop of it under the microscope, three or four thread-like worms were seen actively moving about in it, at one time coiling themselves up in a spiral manner, at another elongating themselves. Every drop of mucus taken from the small intestine contained one or more, and occasional specimens were also found in the mucus both of the large intestine and the stomach. Free ova were also here and there met with of the same size and appearance as those seen in the ovarian tube of the ascaris.

Each of these thread-like worms was about 1-40th inch long, and 1-1000th inch broad, with a pointed and a rounded end (Fig. 3), in size being about two-thirds smaller than the trichinæ met with in the muscles of the same cat. In structure the worm was transparent, so that a canal could be distinctly traced within it from the rounded almost to the pointed extremity. It was somewhat difficult to say whether this canal extended as far as the pointed extremity, or terminated a little on one side of it, although the former is the more probable view. In the middle third, and partly also in the narrower end of the worm, a sacculated or cellular appearance was observed,

apparently surrounding the alimentary canal, and on one side of this a collection of granular matter was seen.

The muscles of this cat, to the naked eye, appeared quite normal; but on placing a portion of the latissimus dorsi under a low magnifying power, several cysts containing trichinæ were seen in it. In the external oblique they were also found, but I did not observe any in the transversalis. In the diaphragm and psoas muscles a few existed, but in smaller proportion than in the more superficial muscles. They were also sparingly distributed in the muscles both of the fore and hind limbs. When the cysts were isolated, and examined under a higher magnifying power, they presented a shape differing from that which we are most familiar with in the human muscle. Instead of being elongated, and possessing one or two well-marked poles, they were almost all round, or with but a slight tendency to the oval form. The walls were thin and transparent, and of an almost uniform thickness throughout the entire circumference, in structure being faintly granular or striated. The cavity within each cyst was round, or nearly so (Fig. 4). Owing to the transparency of the wall, the spiral arrangement of the worm, and even the leading features of its anatomy (which corresponded exactly with those which we are familiar with in human muscle), could be readily examined without rupturing the cyst. In no instance did I see more than one worm in each cyst. Gentle pressure upon the glass cover readily expelled the worm, when it was seen to move about in the fluid. Along with the worm, a considerable quantity of a viscid material, containing granules and numerous nuclei, each with its enclosed nucleolus, was extruded (Fig. 5). These nuclei, or small cells, as they might with equal propriety be called, probably fulfil an important office in connection with the nutrition of the worm, by absorbing from the surrounding textures the materials necessary for its nutrition. Nuclear or cellular particles of a similar nature I have also seen frequently in the trichina cysts from human muscle.

The muscular fibres surrounding the cysts exhibited no appearance of fatty degeneration, neither were there those large collections of fat-cells about the exterior of the cyst, which are so common in the muscles of man.¹ Virchow, in his paper already cited, puts forward the hypothesis, that the trichina lies within the muscular fibre, and not between adjacent ones, as is generally supposed, and that the cyst wall is formed by thickened sarcolemma, and not by hypertrophy of the connective tissue. He bases this view partly upon theoretical grounds, and partly upon the fact that Bowman and others have observed nematoid worms inside the tube of sarcolemma. Although I have made numerous observations bearing upon this point, yet I have not been able to satisfy myself of its correctness.

¹ I may mention, that, in the examination of trichina cysts in the human muscle, especially where the fat-cells have been at a minimum, I have frequently found numerous nuclei lying in the tissue immediately outside the cyst; these were always especially abundant about the poles.

The conclusions which may be drawn from the experiment I have now related appear to me to be the following:—The interval which had elapsed between the feeding and the death of the cat had given time for the trichinæ which it had swallowed to propagate in its intestine. Many of the young trichinæ still remained in the gut, and constituted the thread-like worms which I have described as existing there. Others had emigrated from the gut, and, after working their way into the muscles, had become encysted. The cysts themselves exhibited all the characters of having been recently formed; for they were almost perfectly transparent, and they exhibited no deposition of calcareous particles either in their walls or cavities; besides, there was an absence of fatty degeneration in the muscular fibres surrounding them, and of the deposition of fat-cells in their vicinity. Lest it might be supposed that the thread-like worms found in the intestine of this cat were derived from the ascarides dwelling there, I examined the intestinal mucus of a healthy cat, to which no trichina flesh had been given, but in whose canal living ascarides were present, but no trace of such worms were seen. Moreover, it must be borne in mind, that whilst the *asearis mystax* appears exclusively to inhabit the duodenum and jejunum, the thread-like worms were found both in the large and small intestine.

But, whilst the conclusions which I have drawn tend to explain, more satisfactorily than any other, the sequence of events, yet it must be confessed that certain links are still wanting to render the chain of evidence complete. In such an extensive emigration as must here have taken place, one would have expected to have found indications of the passage of the worm through the intestinal wall; but, although I examined microscopically several dozens of sections made through different parts of the wall, I could see no trace of such passage, neither could I find any worms lying free in the peritoneal cavity. It should be mentioned, however, that Virchow has met with them in the mesenteric glands, and Herbst also has seen them in the mesentery of a small owl. One would also have imagined that those muscles which surround the abdominal cavity—viz., the diaphragm, transversales, and psoas—would have contained the worms in greater abundance than the muscles situated nearer the surface of the body, which was not, however, the case. It was long ago remarked by Owen, that the superficial muscles of the human body were much more abundantly affected than those more deeply situated. In special examinations which I have made of several bodies, I have invariably found this to be the case, the pectoralis major, trapezius, latissimus, and external oblique containing more cysts in a given space than the pectoralis minor, rhomboideus, and internal oblique or transversalis. Moreover, the cysts are much more extensively distributed near the superficial than the deep surface of the same muscle,—a fact of considerable interest, for it shows the tendency which the worms possess to work their way towards the exterior.

When the worms have once reached the muscles and become encysted, they remain dormant, many of them undergoing calcareous degeneration. If it should so happen that the flesh containing them should be swallowed by another animal, then they become developed in its intestine. In Zenker's case, and in the pig fed by Leuckart, the emigration of the worms from the intestine to the muscles, and their presence in the latter, produced well-marked symptoms, which in Zenker's case led to a fatal termination. Up to the present time this is the only recorded instance of death being occasioned by the worm, or even of symptoms being produced which might lead to the supposition that it was present. I have compiled from the various medical journals the following table of recorded cases, and appended to it six cases which have come under my own observation:—

Authority.	Sex.	Age.	Disease.
Owen,	M.	50	Tubercles and Bright's Disease.
"	F.	...	Sloughing Uleer, and Diarrhoea.
"	M.	Aged.	Not stated.
Wood,	M.	22	Acute Rheumatism.
Farre,	M.	Middle Age.	Tubercles.
Curling,	M.	58	Fractured Skull.
"	M.	60	Fractured Ribs.
Gairdner,	M.	60	Purulent Infection of Blood.
Millar,	F.	49	Tumour of Tongue, probably cancerous.
Luschka,	F.	80	Old Syphilitic Disease.
Rainey and Bristowe,	M.	56	Pulmonary and Cardiac Disease.
Henle,	M.	60	Not stated.
Zenker,	F.	20	Pyrexia, Tympanitis, Abdominal and Muscular Pains.
Turner,	M.	60	Paralysis following Apoplexy.
"	F.	79	Old Age and Debility.
"	M.	66	Cancer of Pylorus.
"	F.	49	Unknown.
"	F.	60	Asthma and General Debility.
"	F.	37	Meningitis.

With two exceptions, Wood's¹ and Zenker's cases, the remainder had reached the middle or advanced periods of life, and had died of debilitating disorders—such diseases, in fact, as most commonly terminate life at these ages. No record is given of symptoms which could be referred to the emigration of the worm from the intestine to the muscles, and, if ever these occurred, they were probably so far back in the life of the patient as to have escaped his recollection. That it is quite possible for the active exercise of the muscles to be

¹ *London Medical Gazette*, May 1835.

performed, and for the individual to be apparently in sound bodily health, even with the encysted worm present in the muscles, is proved by the two cases recorded by Mr Curling.¹ These men were both suddenly killed by the receipt of severe injuries, whilst engaged in the performance of severe manual labour.

With regard to the comparative frequency of the trichina in man, I am disposed to look upon it as much more common than is generally supposed, between one and two per cent. of the dead bodies which have come under my observation during the last five years having been so affected.

¹ *London Medical Gazette*, January 1838.

